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Wheeled Vehicles of the Indus Valley Civilization of Pakistan and India.

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Introduction

The Indus valley of northwestern South Asia has long been known as an important center for the emergence of cities and urban society during the mid-third millennium BC. However, it is only in the last two decades that new and more detailed scientific excavations and analysis have begun to reveal the complex processes through which these urban centers emerged (Kenoyer 1998, 2003, Possehl 2002). In this paper I will focus on the early use and gradual development of wheeled vehicles at the site of Harappa, Pakistan, in order to better understand the role of carts in this process of urban development. The earliest Neolithic communities that emerged along the edges of the Indus Valley around 7000 BC do not reveal the use of wheeled vehicles (Jarrige et al. 1995; Jarrige and Meadow 1980), but as sedentary farming communities became established out in the alluvial plain of the Indus river and its tributaries (Figure 1), more effective means of transporting heavy raw material would have been a major concern. In the alluvial plains that make up the core area of the later Indus civilization no rock is available except in the region around the Rohri Hills, Sindh. Before the development of wheeled carts, the transport of raw materials for stone and metal tools, construction materials such as mud brick and timber, and regionally abundant food items would have been accomplished primarily by human porters or possibly in some cases by domestic animals. Although some goods may have been transported by rafts or boats along the many rivers and their tributaries, the transport of heavy items to the settlements would have been quite difficult.

Due to the fact that wood remains are not well preserved from Indus sites and there are no graphic depictions of carts, most evidence for wheeled vehicles comes from terracotta and bronze model carts and wheels dating to the Harappan Phase, circa 2600-1900 BC and rare examples of streets with cart tracks (Dales and Kenoyer 1991:Fig. 13.41; Wheeler 1947: 85, Plate XXXIX; Wheeler 1968:82-83, 92) . Terracotta model yokes similar to modern neck yokes have been found at the site of Nausharo from the Harappa Phase occupations (Period III) and indicate the use of two bullocks for traction, but it is not clear if these yokes were used for pulling carts or agricultural implements (J. F. Jarrige 1994 personal communication).

Early excavators of sites in the Indus Valley and adjacent regions were very interested in discovering the origins of wheeled transport, and even though they did not give up hope for finding early carts in the Indus region, they often fell victim to colonial perceptions of cultural complexity and the simplistic diffusion models that dominated the archaeology of the early 20th century. Unfortunately, both of these problems still plague the field today. The quest for Indo-Aryan horse drawn chariots with spoked wheels in the mid- second millennium BC has also overshadowed the obvious evidence of both heavy and light wheeled vehicles pulled by bullocks that were discovered at sites such as Mohenjo-Daro, Harappa and Chanhu-daro (Figure 1) over 1000 years earlier than the evidence for horse drawn chariots.

Sir John Marshall writes " As far, therefore, as the archaeological evidence takes us at present, the wheeled vehicle originated in Central Asia, and seems to have passed thence to the west about a millennium later. Which people were responsible for the invention, we do not know, but they may well have been the inhabitants of Mesopotamia. We may surmise that it did not come from India, because the ancient vehicles found there are of a more primitive pattern than those found at either Kish or at Ur. But it is too early as yet to dogmatize on this subject, for the lower levels of Mohenjo-daro may prove the contrary." In his footnote 6 on the same page he adds, " I think it may be regarded as certain that the invention was made in an alluvial or non-hilly country." (Marshall 1931, Vol 2: 555).

Due to the problems of a high water table, the early levels of Mohenjo-Daro were never excavated, and subsequent scholars continued to reiterate part of Marshall's discussion, but neglected to heed his caution to avoid dogmatic statements. For example, Mackay continues to regard the Indus carts as being more primitive than those used in Sumer (e.g., Mackay 1943: 164) even though he discovered a wide range of cart types in his excavations at Mohenjo-Daro (Mackay 1938) as well as at Chanhu-daro (Mackay 1943) (see Figure 6). This type of value judgment can be rejected by recognizing that carts in each region were invented and designed for specific functions and in different styles. The long continuity in cart designs of the Indus valley and the fact that many different types of bullock cart continue to be used even today in Pakistan and India indicate that the original styles of cart were quite effective and that the early designers were able to produce a form that came to be improved upon only with the introduction of ball-bearing axles and rubber tires..

In contrast to Mohenjo-Daro, excavations at the site of Harappa by Wheeler in 1946 (Wheeler 1947) and the reanalysis of Wheeler's work by Mughal (Mughal 1970) revealed that the early levels at this major urban center were present and could be reached. In 1986, the Harappa Archaeological Research Project led by the late George F. Dales and the author began a long term excavation project at the site with one of the major goals being the excavation and investigation of the Early Harappan occupation levels (Dales 1989). In 1992, after the untimely death of Dales, Richard H. Meadow of Harvard University and the author continued to pursue and expand on the original project goals. In 1988 and 1996 the early occupation levels of the site were reached on Mound E and Mound AB

respectively (Figure 2), and the evidence that Marshall had anticipated was discovered (see below). He was correct in his assumption that the earliest wheeled vehicles were developed in an alluvial plain, but it was in the Indus Valley itself rather than in Central Asia.

At Harappa we find evidence for the use of terracotta model carts as early as 3500 BC during the Ravi Phase at Harappa (Table 1 and Figure 2). During the subsequent Early Harappan Period (Kot Diji Phase , 2800-2600 BC) we see a period of expansion and site development that corresponds with the emergence of urban culture. During this time there is evidence for many new crafts and mud brick architectural traditions as well as the use of new types of model carts, painted wheels and various types of animal figurines with wheels (Kenoyer and Meadow 2000). These discoveries suggest that the earliest wheeled carts of the Indus valley developed in the core areas of the alluvial plain. Furthermore, functional bullock carts and other forms of wheeled vehicles became more common during the later stages of the Early Harappan period along with the emergence of urbanism.

During the Harappan Period (Harappa Phase, 2600-1900 BC) there was a dramatic increase in terracotta cart and wheel types at Harappa and other sites throughout the Indus region. The diversity in carts and wheels, including depictions of what may be spoked wheels, during this period of urban expansion and trade may reflect different functional needs, as well as stylistic and cultural preferences. The unique forms and the early appearance of carts in the Indus valley region suggest that they are the result of indigenous technological development and not diffusion from West Asia or Central Asia as proposed by earlier scholars.

Table 1. Overall Chronology of the Indus Valley Civilization
Insert table 1

Neolithic and Early Chalcolithic Transport
The earliest settlement with domesticated cattle and the cultivation of field crops such as wheat and barley has been documented at the site of Mehrgarh, Baluchistan in the Kacchi Plain at the edge of the Indus Valley (Jarrige et al. 1995; Jarrige and Meadow 1980, Meadow 1993). Similar settlements were being established all along the Indus plain, but so far only a few of these settlements have been discovered and no new major excavations have been conducted (Siddique 1996). Few if any terracotta figurines were discovered in the aceramic Neolithic. Even when terracotta figurines began to be made in the early Chalcolithic, around 5500 BC, they were dominated by female figurines with occasional male or animal figures. No model carts or wheels have been reported at Mehrgarh or the nearby site of Nausharo during the periods prior to 2600 BC (Table 1). Prior to the Harappan Period, economic and cultural links at Mehrgarh and Nausharo seem to have been oriented primarily to the western highlands where wheeled vehicles may have been impractical for the transport of raw materials or for human travel.

North east of Mehrgarh, out on the Indus plain, one of the earliest well dated settlements is the site of Harappa. Initial occupation at this site begins during the Ravi Phase, which begins around 3500 BC (possibly as early as 4000 BC) and continues to approximately 2800 BC (Kenoyer and Meadow 2000). Other sites dated to this time period on the basis of ceramics have been found to the north and south of Harappa along the Ravi river at Rajanpur and Jalilpur (Mughal 1974) respectively. Additional sites with broadly similar cultural materials were previously discovered during surface surveys along the Hakra River in Cholistan and have been collectively referred to as "Hakra Ware" sites (Mughal 1982, 1997). Both Ravi and Hakra sites represent the same basic level of cultural complexity - i.e. early farming villages in the alluvium with extensive trade contacts up and down the Indus plain and surrounding resource areas.

During the Ravi Phase at Harappa in 1996, humped bull figurines (Figure 3:6, 7) were discovered along with what appears to be a fragment of a model cart with a hollow frame chassis (Figure 4:1). This cart design may have been developed specifically for the transport of heavy loads of grain, wood, stone and other bulk commodities. This possible cart fragment was discovered on a well-preserved house floor, dating to the early Ravi Phase, 3300-3500 BC, along with in situ hand built pottery, hearths, steatite beads and bead manufacturing waste. Numerous carbon dates from primary context hearths associated with the floor, as well as hearths immediately above and below it, provide a range of calibrated dates for the Ravi Phase between ca 39050-2900 BC (2 Sigma calibration) (Table 2). Further excavations in Ravi Phase occupation levels in 1999 and 2000 did not reveal any additional examples of model carts or wheels, but this should not be surprising since the overall area exposed is quite small, approximately 100 square meters. While a single cart fragment is not sufficient to establish the widespread use of wheeled carts, it does indicate that some individuals may have begun experimenting with this technology. The fact that all of the pottery during the early Ravi phase is hand built and that in the later Ravi levels we see the introduction of wheel made pottery could indicate that wheeled carts were in use prior to the development of the potter's wheel in this region.

No carts or wheels dating to this early time period have been reported from any sites in Afghanistan or Central Asia, or even from sites such as Mehrgarh and Nausharo that are located at the edge of the Indus plain. Following the premonition of Sir John Marshall mentioned above, it is now possible to say that, on the basis of the currently available archaeological evidence, the development of Indus wheeled carts appears to be the result of indigenous processes occurring out in the alluvium and not the result of diffusion from mountainous regions to the west.

Table 2: Harappa: Ravi Period Dates from Trench 39 S.
Insert table 2

In the course of the initial occupation at Harappa, the Ravi Phase settlement appears to have grown to approximately 10 hectares in area with possibly two separate mounded areas. There is no indication that the settlement was walled, but by the late Ravi phase, mud brick was being used for building houses.

Wheeled carts would have been useful for the movement of mud brick and timber to the settlement for construction purposes. While carts may have been the easiest method for transporting bulk materials for short distances across the plains, the lack of roads and bridges would have made it difficult to move goods for any great distance. Long distance trade during this early period was probably carried out along the rivers, using rafts or wooden boats to move larger weights of heavy goods down river to major settlements. No model boats have been found at Harappa, but they have been reported from the site of Sheri Khan Tarakai in Bannu, Pakistan, dating to the 4th or 5th millennium BC (Khan, Knox and Thomas 1988:116).

Through the use of careful excavation techniques and fine screens to collect artifacts from all excavation units at Harappa, it is possible to get a good idea about the types of materials being brought from distant resource areas far from the alluvial plain. During the Ravi phase we have a very small number of copper artifacts, carnelian and agate nodules used for making beads, some marine shell from the Makran coast west of Karachi, and some heavily reworked ground stone objects. The amount of ground stone objects at the site is extremely low during the initial period of occupation. This situation can be attributed to the distances over which such objects were carried (100 to 300 kilometers) and the need to reuse and reshape stone until it was too small for practical use. Current studies of the raw materials from the Ravi Phase at Harappa by Law (Law 2003) indicate that some of the ground stone may have come from the Suleiman range, some 300 kilometers to the west and south while other rocks derive from the Kirana Hills 100 km to the north - northwest of Harappa.

The faunal remains from the Ravi phase confirm the presence of *Bos indicus*, the humped zebu that could have been used as a draft animal or also as a pack animal. Ethnographic studies of ordinary cattle used for carrying goods up and down rough terrain indicate that they can carry between 54 to 72 kilograms strapped to their back, though some specialized breeds can carry up to 113 kilos across flat land (Deloche 1980: 248). Sheep and goat generally can carry between 5 to 18 kilograms and cover approximately 8 kilometers in a day followed by rest and foraging (Deloche 1980: 230). During the later Harappan period (2600 BC) large concave grinding stones have been recovered that are approximately 35 cm long, 15 cm wide and 9 cm thick, and weigh around 4 kilos. A strong sheep or goat could possibly carry two small grindstones that were evenly balanced across its back, while a bullock could carry between 10 and 14 grindstones.

Using a modern cart and a pair of bullocks for comparison, an early hollow frame cart could have carried around 50 maunds or 1870 kilos (4114 lbs) which would be the equivalent of around 470 grinding stones or around 270 average sized mud bricks (7.5 x 15 x 30 cm, dry weight 7 kg) used in the construction of house walls. Needless to say, the use of a bullock cart would have dramatically changed the amount of stone, mud brick or wood that could be carried for short distances across the plain. It is not unlikely that the increasing need for these commodities and the need for human transport may have been an important stimulus for the invention and development of specific types of wheeled carts that were introduced in the next major phase at the site.

Early Harappan, Kot Diji Phase Carts and Wheels (2800-2600 BC)
As settlements in the alluvium grew larger it is not surprising to see the emergence of more efficient technologies for transport of heavy and bulk commodities. Larger populations would have stimulated the demand for basic raw materials, tools and commodities, as well as for low bulk, high value items from distant areas. At the beginning of the Early Harappan, Kot Diji phase, around 2800 BC, the site of Harappa had grown to over 27 hectares in area with two distinct mounded areas surrounded by massive mud brick city walls (Meadow and Kenoyer 1994). The construction of these walls, which were around 2.5 metes wide and rose several meters above the plain would have required a substantial input of labor. The use of bullock carts would have greatly facilitated the transport of mud bricks, clay for mortar and plaster as well as water for preparation of the mortar.

During this period we also see a significant increase in ground stone objects such as mortars, pestles and large concave grinding stones. The fact that many of the ground stone pieces have been discarded after only minimal use suggests that grinding stones were more easily replaced and that raw materials from distant source areas were being brought to the site in larger quantities, presumably by a combination of boat and bullock cart. The hollow frame chassis possibly first developed during the Ravi Phase, becomes relatively standardized by the Kot Diji Phase and we also see the introduction of three new types of carts, two of which become more widespread during the subsequent Harappan period. The total area of excavation for the Kot Diji Phase (approximately 165 square meters) is greater than that exposed for the Ravi Phase (100 square meters), and we see a correspondingly higher number of cart and wheel fragments. Seven terracotta cart fragments and seventeen wheels have been recovered from undisturbed contexts that can be securely dated to the Early Harappan Period, 2800-2600 BC. While this size of sample is not sufficient for statistical comparisons with the one example from the Ravi Phase, it does suggest that model carts were more numerous during the Kot Diji Phase and presumably real carts were becoming a part of every day life in the developing urban center. Most of the pottery during the Kot Diji Phase is made on a fast wheel and although there is no direct link between potters wheels and cart wheels, they work on a similar principle of rotation.

Four fragments of hollow frame carts (Figure 4:2, 3) have been recovered from street and house floor deposits in Trench 39N on Mound AB (Figure 2). In nearby street debris, two oval carts with low sidewalls were recovered (Figure 4:4) and one example of a four posted carriage has been found (See Figure 16:1-3 for examples). These two varieties of cart may have been designed to be lighter and the side walls were probably a safety precaution to keep people and small commodities from falling out as they moved across the bumpy plain. The lighter form of cart would allow more rapid movement and therefore may have been used primarily for transport of humans rather than for heavy goods. While it is not appropriate to call these two wheeled carts chariots, some of them are quite small and may represent vehicles that were used by a single rider for racing or fast transport. In modern Sindh, specialized racing carts with a pair of young bullocks are used in local competitions and empty carts are often raced along the

highway by young boys standing on the cart like an ancient charioteer (Figure 14:3). The standing position allows the knees to absorb the shock of the bumpy road, but it requires great leg strength and balance.

A third cart form has long narrow chassis with low side walls (Figure 4:5) and two sets of holes along the sides for attaching axle pieces. Although it lacks the upturned end portion, this Kot Diji Phase cart is structurally similar to the two unique forms from the Harappan Period at Chanhu-daro, illustrated by Mackay (Mackay 1943:Plate LVIII, 9, 13)(Figure 6: 13, 14).

Ram and painted bull figurines (Figure 3.1) with holes for attaching small wheels also were made during this period, indicating the common use of the wheel in different contexts. The increase in bull figurines and the use of painting to indicate decorated blankets also suggest that cattle were highly valued and cared for during this period. The different styles of bull figurines may indicate different ethnic groups who had distinctive art traditions, and the modeling of some figurines with pronounced humps and others with only low humps may reflect the presence of different local breeds of cattle (Figure 3:1-5). Not all cattle are suitable for use in pulling carts, and with the increased importance of cart transport and travel, we can assume that specialized breeds of cattle began to be developed by farmers and herders.

Terracotta wheels during this period show diversity in size and shape as well as in decoration. All Kot Diji Phase wheels found at Harappa have a short, truncated conical hub on one face and are flat on the obverse side. Some wheels are relatively small (Figure 4:1, 2) and may have been for wheeled animals or small carts. Out of fourteen wheels, four (28.57%) have painted motifs preserved. The painted designs on the wheels were made with black paint prior to firing and three different painted design styles have been recovered so far. One design shows radiating lines (Figure 4:2) that could represent spokes or some form of wheel construction using lashings or support bands. The other two examples show the more common form of decoration that is made up by multiple concave lines consisting of double or triple strokes along the edge of the wheel (Figure 4:3, 4). These painted designs could be simply decorative or represent the actual wheel construction. One example also has four tiny painted circles that may represent dowels or rivets (Figure 4:4). If the decorations reflect actual construction it is possible that they depict the hollowed side wall with supporting spokes, a technique used today in Punjab and Sindh to make the wheels lighter, but still strong enough to carry heavy loads (Figures 10 and 14).

By the end of the Early Harappan period, the basic technology for wheeled transport had become well established at the site of Harappa, but this technology is not well attested at other Early Harappan sites in the Indus Valley. For example, no terracotta carts have been reported from the Early Harappan levels at Nausharo (Jarrige 1986, 1989, 1988), Rehmandheri (Durrani 1988; Durrani, Ali and Erdosy 1991), Kot Diji (Khan 1964, 1965), or Kalibangan (Thapar 1979). It is also important to note that no carts or wheels have been reported from contemporaneous sites in the regions surrounding the Indus valley. Sites such as Damb Sadaat and Kili Gul Mohammad in the Quetta valley (Fairservis 1956),

Mundigak in southern Afghanistan (Casal 1961) or Shah-i-Sokhta in Eastern Iran(Tosi 1968) have many bull figurines, but no terracotta wheels or carts.

Further north in Central Asia, the first carts appear during the subsequent Namazga V period (2600-2200 BC) that corresponds to the Harappa Perior in the Indus Valley, and these are four wheeled carts drawn by one or two camels and not by bullocks (Masson 1988) (Figure 5:1, 2). Since camels were not domesticated in the Indus valley, we can assume that the use of camel carts is an indigenous process in Central Asia and that the construction of four wheeled carts in Central Asia is also a local phenomenon. Although four wheeled bull and ram figurines are found during the Kot Diji Phase at Harappa and other sites, no four-wheeled carts have been found during this period.

The multiple designs for carts at Harappa during the Early Harappan, Kot diji Phase occupation could be the result of local elaborations of the technology or they may reflect different regional cart styles that were brought together in the emerging urban setting. It is not unlikely that future excavations at sites in other regions dating to this time period will reveal that carts were also being developed and used in other parts of the Indus plain. However, at the present time it is too early to make any further conclusions about the Early Harappan period carts of the Indus Valley region due to the limited excavations of this occupation at Harappa and the lack of comparative material from other sites.

Harappa Phase Wheels and Carts (2600-1900 BC)

Excavations at Harappa have for the first time made it possible to quantify the different styles of carts and wheels, and also provide an overall chronological framework for the introduction of new cart styles during the Harappa Phase. Due to limited space only a brief summary of the analysis is presented here, but it will demonstrate the significant increase in the total number of terracotta cart and wheel fragments, as well as numerous styles and sub-varieties of both categories of artifacts. Unfortunately, it is not possible to compare the new information from Harappa with the earlier excavations at this site or with other major sites of the Indus valley due to the fact that the earlier excavation reports did not include detailed studies of the small finds. Earlier excavators presented the rare and unique examples, with very little discussion of the most common forms. The diversity of model carts found at Indus settlements is quite significant (Figure 6) and it is unclear why scholars have ignored the complexity and specialization of Indus transportation technology that they represent. The solid frame chassis appears to be the most basic form, but various hollow frames and compartmented carts indicate many different functional styles. The most important cart models discovered from Harappa and Chanhu-daro were made from bronze and were equipped with drivers and canopied compartments. Subsequent authors have often focused on these rare examples uncritically, and this has resulted in the perpetuation of incorrect information and also misconceptions about the nature of cart and wheel technology of the Harappan Period. In the course of the following discussion some of the misperceptions and errors in the earlier reports will be addressed.

Single Draft Animal Carts

The discovery of small compartmented carts and the bronze examples with the roofing prompted Mackay (1943: 162-163) to suggest that some Indus carts were for carrying people and that they were similar to the *ekka* carts that are still seen throughout northern India today. Mackay or other European scholars appear to have used the term *ekka* to mean a small vehicle for carrying people, but in fact the term refers to a cart drawn by a single *(ekka)* animal. The fast moving horse or donkey are the most common animals used in the north today, but in some instances farmers will use the slower bullock. However, there is no conclusive evidence in the Indus valley for the use of a cart drawn by only one animal. The bronze cart models from both Harappa and Chanhu-daro have a chassis made with two side beams and four cross bars with the covered section placed in the middle of the cart. The front portion of the cart is broken and there is no indication where the yoke shaft was attached, so it is not clear if this was a cart drawn by a single animal or a pair of animals. The rear portion of the cart shows two projecting sidebars that are similar to those seen on the terracotta hollow frame chassis (Figure 6:2). However, a second bronze cart published by Mackay (1943: 164) is similar in structure to the hollow frame terracotta carts, but in this example, a figurine of a man holding a stick is seated on the front crossbar of the cart with his feet on the shaft, a position that is common for cart drivers even today (Figure 6:15, 16). The shaft for this cart is clearly designed for a pair of draft animals. The wheels have no projecting hub on either the interior or exterior and the sides of the cart were made with simple uprights connected with an upper and lower cross bar that serves as a wheel guard, much like the standard Punjabi carts still being used around modern Harappa (Figure 10).

Rao (1985) perpetuated the myth of the *ekka* type cart, but he was referring to a totally different type of terracotta cart made with double curved side bars that would have been joined with multiple wooden cross bars (Figure 12). Rao's motivation for identifying the *ekka* is linked to his desire to find a cart pulled by a single animal such as the horse, possibly to strengthen his interpretation that horse figurines have been found at Lothal (Rao 1985:504-505). He eventually concludes that horse drawn chariots and their Indo-Aryan owners were present in the Indus Valley cities. At Harappa, an example of what may be a miniature version of this type of cart, made as a single unit, was published by Vats (1940: Plate CXX, 5) (see Figure 6:8). This example is clearly equipped with a hole for a wooden shaft that would have hooked up to yoke for a pair of draft animals rather than a single animal. Although no conclusive evidence has been presented for the use of a light vehicle drawn by a single animal or *ekka*, there is considerable evidence for small light vehicles drawn by two animals or *jori* and numerous examples have been discovered at Harappa (Figure 6:12).

Four wheeled Carts

A second misconception begun by Mackay and perpetuated by Wheeler and others is the use of four wheeled carts. The basis for this identification is the discovery of two fragmentary objects that had two sets of holes on the sides (Mackay 1943: 163, Pl. LVIII, 9 and 13) (Figure 6:13, 14). Mackay suggested that these objects were a type of four-wheeled cart with a raised front panel to shield the occupants. This cart form appears to have been the basis for comparisons

with carts in Anau III (Piggott 1952:209) and four wheeled camel carts at Altyn Tepe (Masson, 1988: Plate XIX, 1) (Figure 5). There is no question that trade contacts existed between the Indus and central Asia, but since no carts of this type have been found at any other Indus sites, more conclusive examples are needed to determine if in fact four wheeled carts were used in the Indus valley during the Harappan period.

Wheels

Numerous different types of wheels have been reported from the Harappan Period at sites throughout the Indus valley, but the most common form is flat on one side with a short truncated conical hub on the other (Figure 7:3-14). At Harappa this is the predominant wheel form; out of 552 wheels with the hub portion preserved 488 (88.41%) have this form. This type of wheel is also reported from most excavated sites; e.g. the highland site of Shortughai in Afghanistan (Francfort 1989), Chanhu-daro in Sindh (Mackay 1943:165, Pl. LVIII, 3), Nausharo in Baluchistan (Jarrige 1989:39, Pl. XV A right), and Lothal (Rao 1985:504-505) in Gujarat.

Another type of wheel is flat with no raised hub (Figure 7:1, 2). At Harappa only 9 (1.63 %) examples have been recovered. This type is also reported from sites such as Lothal (Rao 1985: 505), Kuntasi (Dhavalikar, Raval and Chitalwala 1996:240), and Chanhu-daro (Mackay 1943:165, Pl. LVIII, 24). There are other less distinctive hub types at Harappa that have an irregular profile (Figure 7:15) and at Chanhu-daro one type of wheel has no hub, but is slightly convex on both faces (Mackay 1943:165, Pl. LVIII, 23). This latter form has not been found at Harappa. At Lothal, Rao reports the presence of a wheel with hubs on both faces (Rao 1985) p. 505), similar to those found at Altyn Tepe (Figure 5:1), but no wheels with double hubs or bushings have been recovered from excavations at Harappa, Chanhu-daro or Mohenjo-Daro.

Only 62 wheels (9.3%) with painted designs have been recovered from the Harappa Phase levels at Harappa. This percentage is much lower than for the Early Harappan Period (28.5%) and indicates that during the height of the urban period, terracotta wheels were being produced in large quantities with little effort expended in decoration. Nevertheless, the painted motifs on wheels have stimulated considerable discussion regarding the construction of the actual wheels used with Harappan carts. At Chanhu-daro one example of a wheel (Mackay 1943:Pl. LVIII, 20) (see Figure 8:1) is painted on both faces with a wide band that Mackay has interpreted as indicating that the wheels were made of three solid pieces of wood presumably joined together with tenons, as well as some form of battens or lashing. No other examples of wheels painted with this design have been reported at major sites such as Mohenjo-Daro or Harappa, or at any other Indus site. Unfortunately, Mackay's statement about the solid wheel construction has become so widespread that most scholars assume all wheels of the Indus valley were made in this manner. In fact most of the painted motifs consist of diagonal bands that cut across the outer hub face of the wheels and may indicate a type of hollow wall design, a spoked wheel or a composite wheel. One variety includes single or multiple strokes in sets of two, three (Figure 7:9-11) or four, while another style has curved strokes in sets of four or more (Figure

7:12-14). These styles appear to derive from the Early Harappan painted designs. A third style consists of a spiraling or concentric circle motif that was painted on both faces of the wheel (Figure 7:15).

The most controversial discussion revolves around the construction of spoked wheels that have been associated with the use of the horse drawn chariot and by extension, the Indo-Aryan culture. In India single examples of "spoked wheels" have been reported from the sites of Lothal, Rupar, and Mitathal, (Dhavalikar, Raval and Chitalwala 1996:240), Banawali (Bisht 1987:150) (see Figure 8:3, 4) and most recently at Rakhigarhi (Lal 2003) (see Figure 8:2). At Lothal a painted wheel with no hub has two crossing lines that are thought to indicate a wheel with four spokes (Rao 1985: 505, Plate CCXXII B, 1), but it is not clear if it has a hub on the opposite side. The approximate diameter is 6.8 cm, which is in the range for average terracotta model cart wheels. However another example of a spoked "wheel" from Kuntasi (Dhavalikar 1974: Fig. 7.40) is less convincing. The Kuntasi example has numerous black painted lines radiating out but the size of the wheel is 11.8 cm in diameter, while the two carts found at the site measure only 8 to 9 cm in length. A closer examination of the drawing and photograph suggest to me that this is not a wheel at all. The concavity of the painted surface suggests to me that it may have been a lid of painted bowl that was later perforated. The photograph shows wheel-throwing marks and the base profile looks as if it was cut off a hump of clay on a potter's wheel. The so called "spoked wheels" from Banawali (Figure 8:3, 4) are also problematic since they do not have any painting and the spokes are thought to be indicated by a textured surface resulting from the forming process. Perhaps the most convincing example of a spoked wheel comes from the site of Rahkigarhi, presumably from the Harappan levels (Figure 8:2) though the excavation report has not yet been published. In this example there are eleven radiating spokes that would have provided considerable support to a light outer rim.

While it is possible that the painted motifs on terracotta wheels, such as the spiral design, are simply decoration, the diagonal or curved strokes or the radiating band motifs may in fact represent basic features of actual wheel construction. In constructing a wooden wheel the major goal is to attain maximum load bearing strength while at the same time reducing the weight of the wheel so that more load can be placed in the cart. Modern Punjabi and Sindhi cart wheels provide examples of two different methods for achieving this end. In the Punjabi wheels, multiple layers of wood are joined together to form the outer wheel and sets of double spokes attach the wheel to the central hub (Figure 10). The Sindhi cart wheels are made with larger pieces of wood with a hollowed out section of two sides of the hub. Sometimes additional spokes are added to the wheel to provide strength (Figure 14:1). Given the high technical skill of Indus craftsmen, it seems unwarranted to assume that they did not have the ability to make wheels for specific purposes.

Table 3. Harappa Cart Fragments 1987-2001: Summary Percentages.
Insert table here

Carts

Although the earlier excavators found many different types of carts at Mohenjo-Daro and Harappa, they did not carry out any stylistic analyses or quantitative studies. Excavations at Harappa have recorded almost 2800 terracotta cart fragments from the Harappa Phase occupation levels, which for the purpose of this paper have been grouped into eight major categories identified by type numbers (520, 530, etc.) assigned for artifact tabulation (Table 3), with short descriptions of each artifact provided in the figure captions. A total count of the different types of cart fragments is presented in Table 3, but it should be noted that this is a summary of a much more complex data set that is still being analyzed. The large number of cart fragments for the hollow frame chassis (Types 520 and 530) is due in part to the fragile nature of terracotta cart models and the fact that the hollow frame chassis often breaks into five or six pieces. Other cart types often break into four fragments while some are usually found broken into two pieces. In order to get a better handle on the percentages of different types, the total number of fragments has been divided by the estimated breakage factor that corresponds to the cart type. While this is a very rough method for dealing with the fragmentary data, it does have its merits in allowing for a comparison between different data sets.

Flat solid chassis (Type 540) (Figure 6:1)

This type of cart frame is the simplest form having a solid, flat rectangular body with square or rounded edges. A series of four to six holes along each side of the cart allows for the attachment of side bars and axle holder as in the hollow frame carts discussed above. Although only a twelve examples have been found at Harappa, this type of cart is widespread at many Indus site, including Shortughai (Francfort 1989:168, Pl. 62, 6), Nausharo (J. F. Jarrige 1994, personal communication), Kuntasi (Dhavalikar, Raval and Chitalwala 1996:240, Fig. 7.37:1), and Lothal (Rao 1985:Pl. CCXXII, A, 1). One variation of the flat solid chassis at Lothal has short projections at each end (Rao 1985:Pl. CCXXII, 2). The flat chassis and solid frame may indicate this type of cart was used for carrying heavy loads, such as stone or large storage jars filled with oil, that would not be supported as easily on a hollow frame with matting.

Hollow Frame Chassis - Rectangular Plan (Type530) (Figure 9)

The most common cart type at Harappa (1737 examples) is the hollow frame chassis that had its origins in the Ravi Phase and continued on into the Kot Diji Phase. This cart type appears to have been a very popular form because it is found at almost all major Indus sites; e.g. Mohenjo-Daro (Marshall 1931) p. 544-555, Pl CLIV, 7, 10), Shortughai (Francfort 1989:168, Pl. 62, 7-9), Nausharo (Jarrige 1989), Lothal (Rao 1985:Pl. CCXXII, A, 4, 5), Kalibangan, and Dholavira. The hollow frame carts (Type 530 and 520) appear to have been designed to carry large bulky loads such as straw, bricks, firewood, etc. and the hollow sections would have been created to reduce the overall dead weight of the cart. The hollow frame chassis has a rectangular plan form with projecting side bars and the bed of the cart is relatively flat. Hollow frame chassis were often painted with red or black painted hatching that may represent a net or matting used to cover the hollow areas of the chassis (Mackay 1943)(Figure 9:6-10).

As noted earlier, the modern Punjabi cart (Figure 10) with side bars and matting on the floor is probably the direct descendant of this optimal form. Modern carts have been equipped with additional wheel guards and are perfectly balanced to allow ease of loading and traction. In modern carts, the wheels rotate on bearings and the axle is fixed to the frame. Although some scholars have assumed that Indus carts had solid wheels fixed to rotating axles as is the pattern in modern Sindh, there is no way to test for this given the nature of the archaeological record.

Hollow Frame Chassis, Concave End (Type 520) (Figure 11)
This is the second most common cart type at Harappa (722 examples), but unlike the rectangular plan chassis discussed above (Type 530), this form has only been reported from Harappa and Mohenjo-Daro (Mackay 1938:569, Pl. CVI, 38). One example can be identified from Lothal on the basis of a published photograph (Rao 1985, Pl CCXXII, A, 3). It is not unlikely that once scholars know how to differentiate the two styles this form will be found at more sites. The basic structure is similar to cart Type 530, but the manufacturing process is different. Most of the carts of this type were undecorated, but a few examples with black painted lines and hatched motifs have been recovered (Figure 12:3-4).

Double side frame chassis (Type 570) (Figure 12)
The double side frame chassis is made from two separate side pieces that would have been joined with small wooden dowels. Several different varieties of this type have been found at Harappa (17 examples) and similar subvarieties have been reported from Lothal (Rao 1985:pl CCXXII, A, 7-9), as well as from Kuntasi (Dhavalikar, Raval and Chitalwala 1996:240, Fig. 7.37: 2). The examples from Harappa and Lothal have two holes at the base of the protruding axle holder that would have held small wooden dowels for fixing the axle. The example from Kuntasi has a lateral hole through the projecting axle holder in which the axle rod would have been fixed. This is the type of cart that Rao suggests is the forerunner to the *ekka* type cart that is now mostly found in northern India. However, as noted above the *ekka* is a cart drawn by one animal, usually a horse, and there is no clear evidence for carts drawn by a single animal and no conclusive evidence that the horse was used for traction or any other purpose by people of the Indus cities (Meadow and Patel 1997, 2002).

Flat solid chassis with side board and projecting shaft (Type 560) (Figure 13)
While all of the other carts described for the Harappan period have some connection with the Early Harappan cart styles, this variety (12 examples) appears first during the middle of the Harappa Phase around 2450 to 2000 BC (Period 3B/C). When it was first discovered in 1988, this cart type was thought to represent an abstract human figurine dating to the Early Harappan or Kot Dijian period (Dales and Kenoyer 1991:230, Fig.13.32, A). Over the course of subsequent excavation seasons additional examples revealed that this was in fact a form of cart with a solid body and low side boards. Two perforations at the center of each side of the cart were used to anchor the axle. The projecting portion at the front of the cart has a perforation for attaching the shaft, linking the cart to the yoke. Some of the carts are plain, but others have been painted completely black or decorated with horizontal bands and hatching. At first it was thought that all

such carts belonged to the Early Harappan period stemming from the original misidentification as a Kot Diji Phase figurine. However, a careful examination of all excavation units from which these cart fragments have been found indicates that they first begin to appear at Harappa during Period 3B and possibly at the beginning of Period 3C. Although no other sites in the Indus region have reported this type of cart, its striking similarity to modern Sindhi carts (Figure 14) suggests that we may find other early examples in the southern Indus valley.

Oval chassis with compartment (Type 547) (Figure 15)
Carts with a flat chassis with low sided compartments have many sub varieties at Harappa. Some have an oval plan (27 examples) while others have a square or rectangular plan (5 examples). Additional variants have been reported from Chanhu-daro where Mackay found two examples of carts that were divided into two compartments (Mackay 1943:Pl. LVIII, 19) (Figure 6:10, 11). Many of the compartment forms have been painted using black or red pigment, with hatched lines or sometimes with horizontal and oblique lines (Figure 15:3, 4). Mackay suggested that the painting on the cart from Chanhu-daro may represent netting or basketry (Mackay 1943:Pl. LVIII). Two holes for the axle were perforated on either edge, and sometimes, additional holes for side bars were added. The shaft for the yoke was inserted through a hole at one end (Figure 15:4, 5).

Four-posted compartment (Type 505/510) (Figure 16)
Four-posted compartment carts are found at Harappa (236 examples) as well as at Mohenjo-Daro (Mackay 1938:569, Pl. CVI, 37), but no examples have been reported from other major sites. Like other compartment carts, the four-posted compartment cart does not appear to have been designed to carry heavy loads, but rather to carry a few passengers or even just a single rider. The four posts usually have a flaring top section that has a flat or concave surface, sometimes decorated with a small dot of clay (Figure 16:1, 3). One variety was made without the four corner posts, but in all other respects it has the same distinctive shape (Figure 16:4). Only a few examples of carts with black painted decorations have been found (Figure 16:5) and the banding or hatching is very similar to that seen on the other types of enclosed compartment carts.

Late Harappan Wheels and Carts (1900-1700 BC)
At the end of the Harappa Phase the site of Harappa and many other sites throughout the Indus valley began to undergo major reorganization (Kenoyer 1998). Major changes in trade networks resulted in the isolation of Harappa and other northern Indus sites from contact with resource areas to the south as well as to the northwest (Kenoyer 1998). Even in the face of major changes in ideology (e.g., burial traditions) and the disappearance of standardized weights and Indus script, carts continued to be made and used in cities such as Harappa.

Seven wheels with the standard type of hub on one face and a flat surface on the other have been recorded from securely dated levels of a Late Harappan house on the northern part of Mound AB. In addition, three hollow frame chassis, three four-posted compartment carts, and one solid flat rectangular example have been recorded. The continuity of these important modes of local transport is not surprising since these cart forms were extremely efficient and Harappa

continued to be a thriving city. Although the Late Harappan period at Harappa can only be dated to around 1700 BC, the overall period extends much later in other regions (see Table 1) and overlaps with later cultural traditions such as the Painted Grey Ware Culture in the north (Kenoyer 1998) and Peninsular Chalcolithic cultures to the east. It is during this time period that we see the spread of the hollow frame chassis cart to peninsular India at the site of Inamgaon in the central Deccan. No cart fragments have been reported by the excavator, but a unique incising on an Early Jorwe pot depicts a two wheeled cart pulled by two humped zebu bullocks (Sankalia 1974:505, Fig. 204) (Figure 17). Sankalia attributes this pot to the Early Jorwe period, 1600-700 BC, while the Allchins suggest a shorter chronology ca. 1500-1050 BC (Allchin and Allchin 1982:273). Both dates correspond to the Late Harappan Period of the Indus cities, a period of restructuring that was followed by the emergence of new elites during the Vedic period who spoke Indo- Aryan languages.

The Early Jorwe pot with the cart incising is contemporaneous with four copper sculptures from the site of Daimabad that have been associated with Late Harappan and post-Harappan cultures in this region of western India (Allchin and Allchin 1982:280-281, Fig. 10.15; Sali 1986). However, the precise dating of the sculptures is still problematic and they may belong to a much later period. One of the Daimabad sculptures depicts a "charioteer" standing in a small chariot reigning in a pair of long legged humped zebu. The modeling of the figurines and lost wax technology are not at all related to Harappan crafts, so it has often been assumed that this "charioteer" represents a new transportation technology, one that is traditionally associated with Vedic, Indo-Aryan culture. However, as noted above, several varieties of light weight model carts have been discovered in the Indus cities and although the metallurgical techniques used at Daimabad may be unique, the cart itself and the pair of humped zebu suggest that this may be a regional expression of an ordinary Indus cart style.

Conclusion

Considerable research still needs to be undertaken on the regional styles of carts and wheels in the Indus valley region, especially during the Ravi and Kot Dijian Phases of the Early Harappan period. On the basis of initial results from the analysis at Harappa, the process of bullock cart development in the Indus valley appears to be the result of indigenous invention rather than the diffusion of a technology from other regions. During the course of the Harappan period, the wide diversity of cart types may have been stimulated in part by exposure to different cultural traditions as well as continued local elaboration of an important form of transportation. However, the evidence for trade contacts between the Indus Valley and adjacent regions, such as Mesopotamia and Oman, as well as Central Asia, make it necessary to begin new research on the use of carts and wheels in these regions to determine the extent of cultural borrowing as well as the directionality of any movement of vehicular technology. The presence of an Indus style cart motif on a pot from Inamgaon and the model bronze "chariot" at Daimabad raise important questions about technological diffusion, replacement and synthesis that will have to await more detailed archaeological study. This paper is an initial attempt to provide scholars in other regions with the most up-to-date and comprehensive summary of the Indus style

carts and wheels in order to provide a foundation for more in depth comparative studies.

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Wheeled Vehicles of the Indus Valley Civilization of Pakistan and India.

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Table 1. General Chronology of the Indus Valley Tradition

Late Harappan Period	**ca. 1900 to 1300 BC.**
Harappa: Periods 4 and 5	1900- 1700 BC.
Harappan Period	**2600 to 1900 BC.**
Harappa: Period 3C, Final	2200-1900 BC.
=Nausharo, Period IV	2100-2000 BC
Harappa: Period 3B, Middle	2450-2200 BC.
=Nausharo, Period III	
Harappa: Period 3A, Initial	2600-2450 BC.
=Nausharo, Period II	
Early Harappan Period	**ca. 5500 to 2600 BC.**
Harappa: Period 2, Kot Diji Phase	2800-2600 BC.
Harappa: Period 1, Ravi Phase	> 3500-2800 BC.
= Mehrgarh, Period IV to VI	3500-2800 BC.
Mehrgarh, Period III	4800--3500 BC.
Mehrgarh, Period II	5500-4800 BC.
Neolithic Period	**ca. 7000 to 5500 BC.**
Mehrgarh, Period 1, Aceramic	7000-5500 BC.

Table 2: Harappa: Ravi Period Dates from Trench 39 S.

YEAR	LOT	FEATURE	CONTEXT	Lab Number	RESULTS	BC DATES +2 sigma	+1 sigma	Intercepts	-1 sigma	-2 sigma
1996	7499	115	hearth 115	WG(NEC)-2518	4980±60 bp	3945	3893	3763 3718 3714	3672	3646
1996	7502	120	hearth 121	Beta-179361	4990±40 bp	3938	3889	3772	3708	3662
1996	7507	127	hearth 128	Beta-93759	4210± 50 bp	2907	2885	2877	2701	2604
1996	7525	177	hearth 177	Beta-93760	4320±50 bp	3082	3006	2911	2887	2878

Table. 3. Harappa Cart Fragments

Major Cart Types	Number	%	# of Frags	MNO*	MNO %
Square -compartment (Type 546)	6	0.22	/ 2 frags	3	0.51
Solid - side board (Type 560)	6	0.22	/ 2 frags	3	0.51
Flat solid chassis (Type 540)	12	0.43	/ 2 frags	6	1.03
Double side frame (Type 570)	17	0.62	/ 2 frags	8.5	1.45
Oval- compartment (Type 547)	27	0.98	/ 2 frags	13.5	2.31
Four posted (Type 505/510)	236	8.54	/ 4 frags	59	10.09
Hollow Frame concave end (Type 520)	722	26.13	/ 5 frags	144.4	24.69
Hollow Frame – (Type 530)	1737	62.87	/ 5 frags	347.4	59.40
total	**2763**	**100.00**		**584.8**	**100.00**

* the MNO or minimum number of object specimens is based on the approximate number of fragments estimated for different types of carts. This is a rough number but is more accurate than the total number of fragments listed at the left.

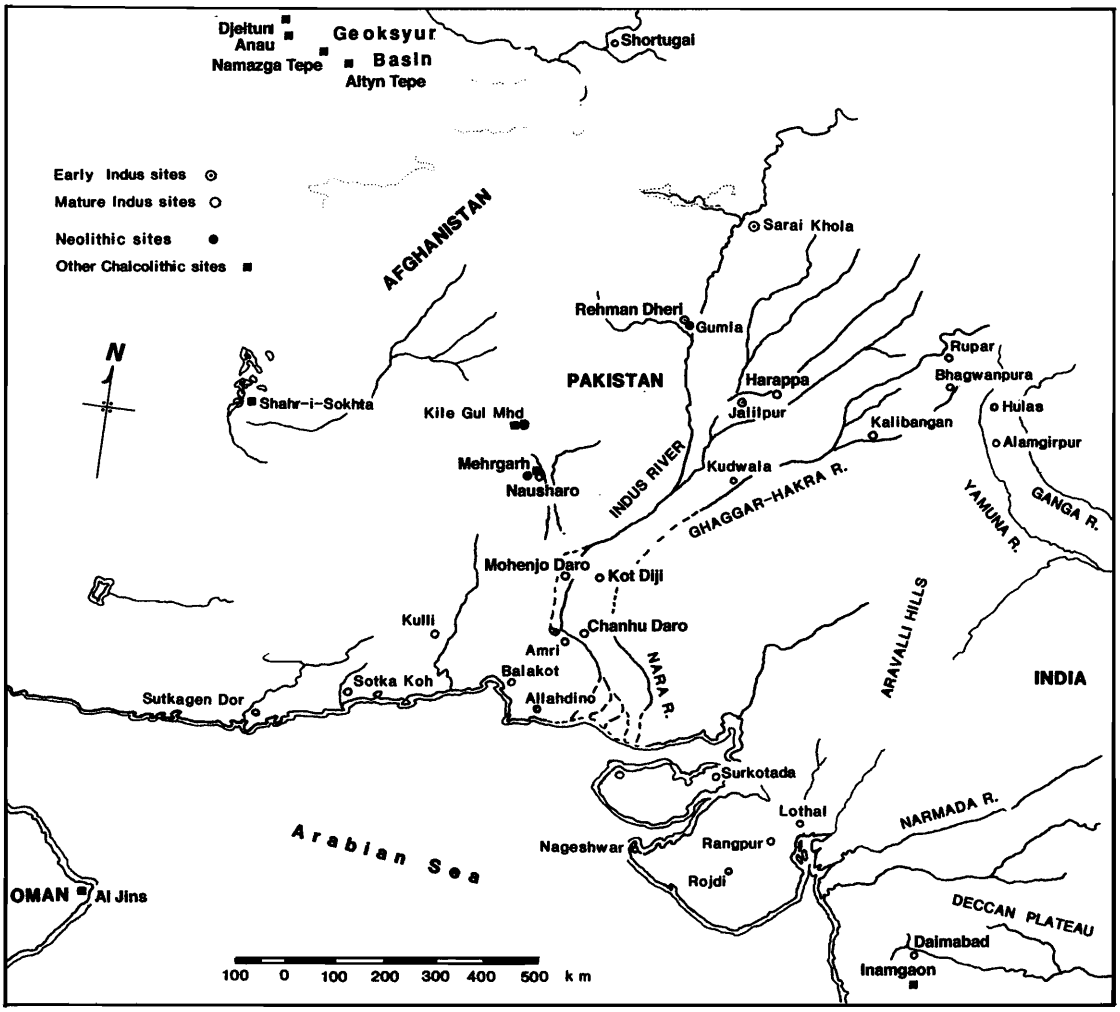

Figure 1. Major sites of the Indus Valley and Adjacent Regions.

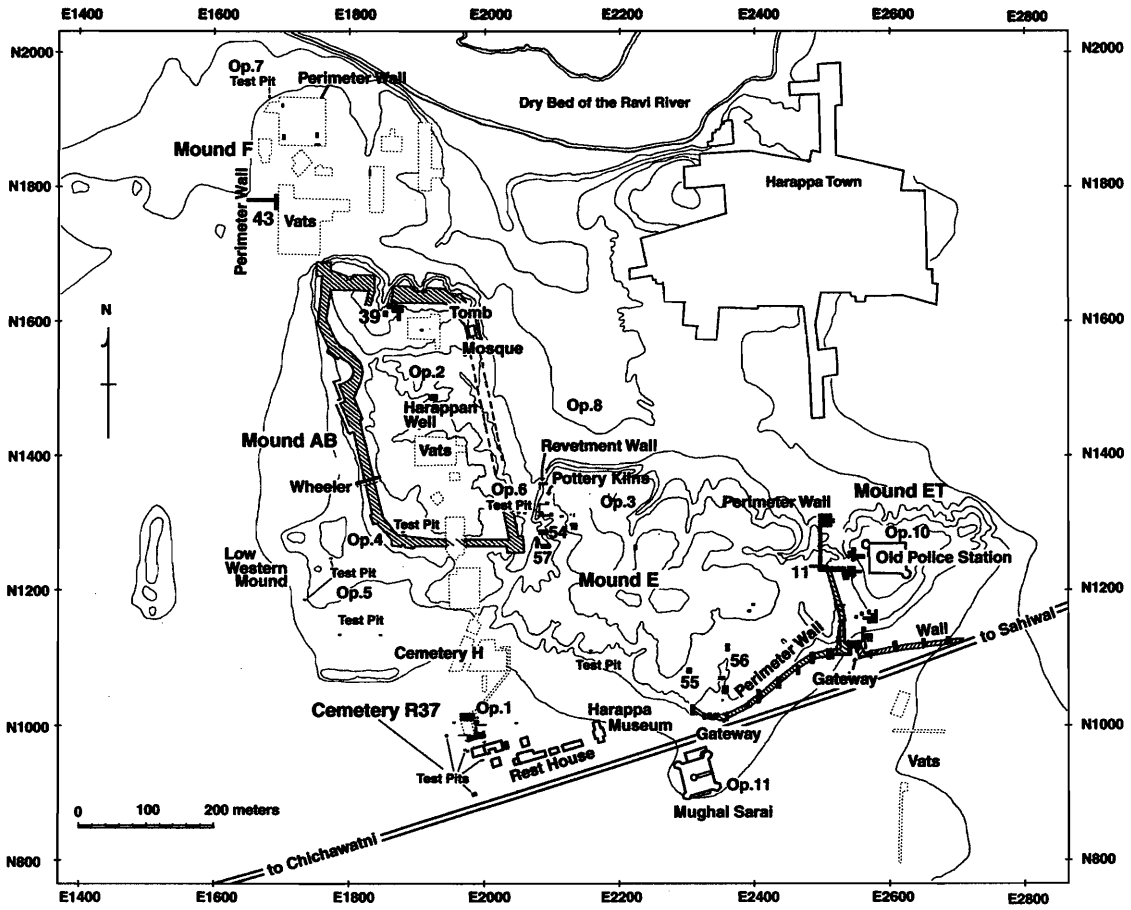

Figure 2. Harappa site Map showing locations of major excavation areas.

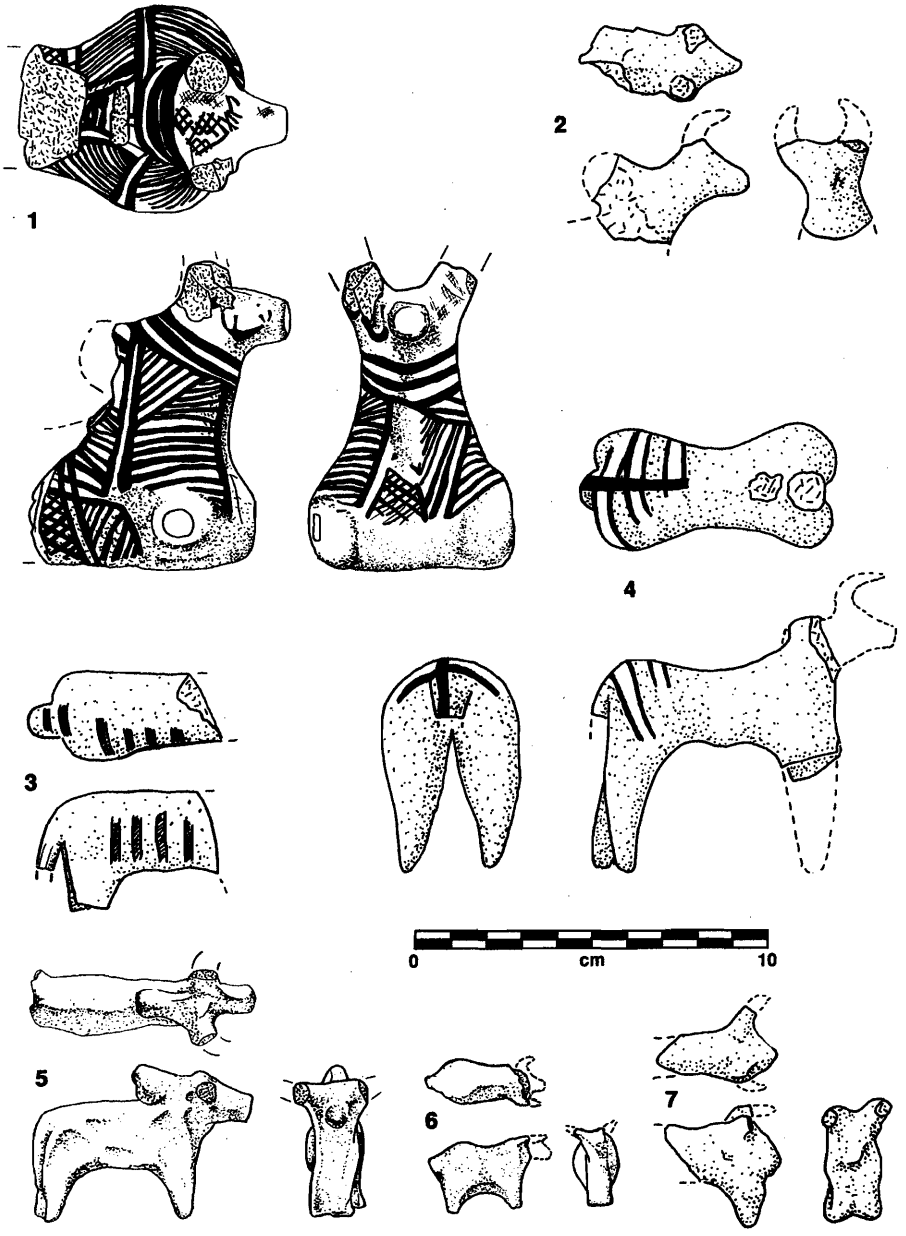

Figure 3. Harappa: Ravi and Kot Diji Phase Animal Figurines.

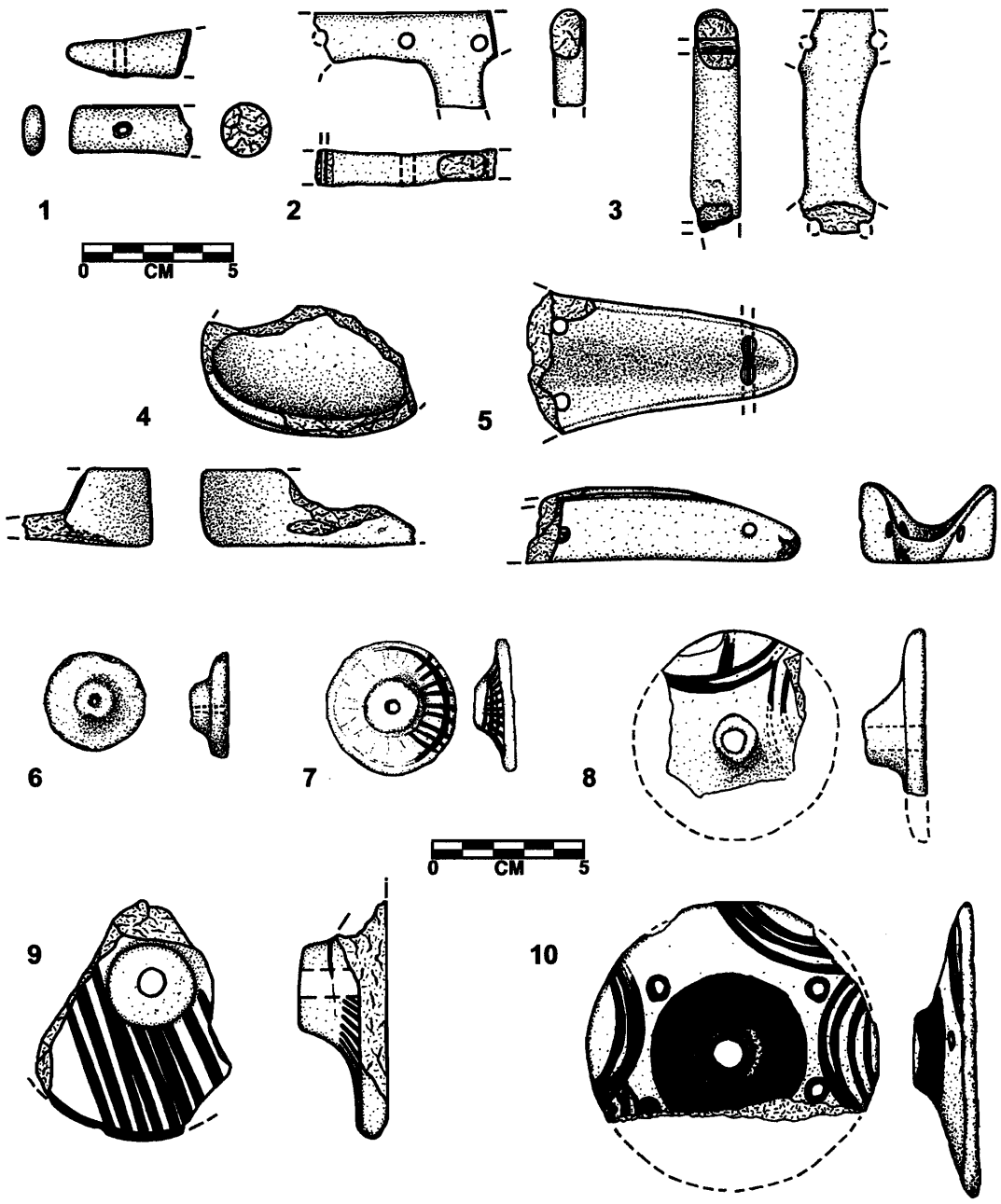

Figure 4. Harappa: Kot Diji Phase Terracotta wheels types.

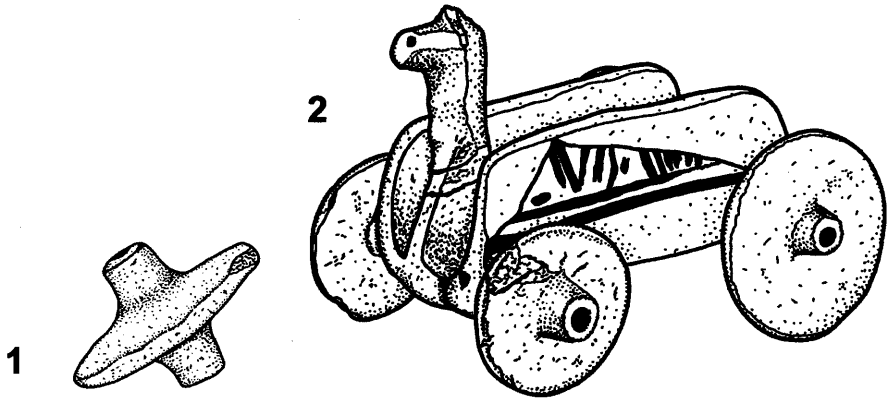

Figure 5. Altyn Depe Animal-Carts.

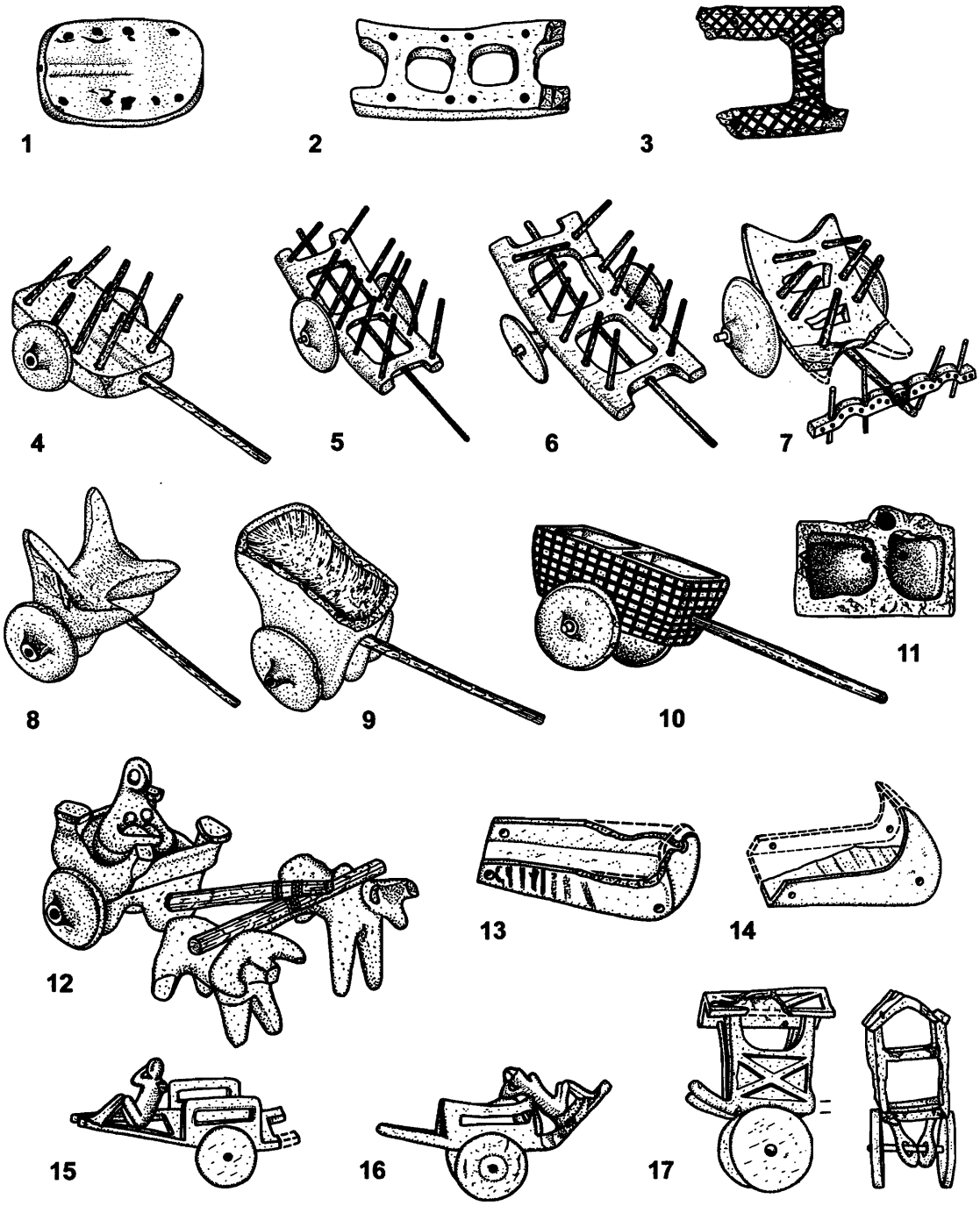

Figure 6. Indus Cart Types from early publications.

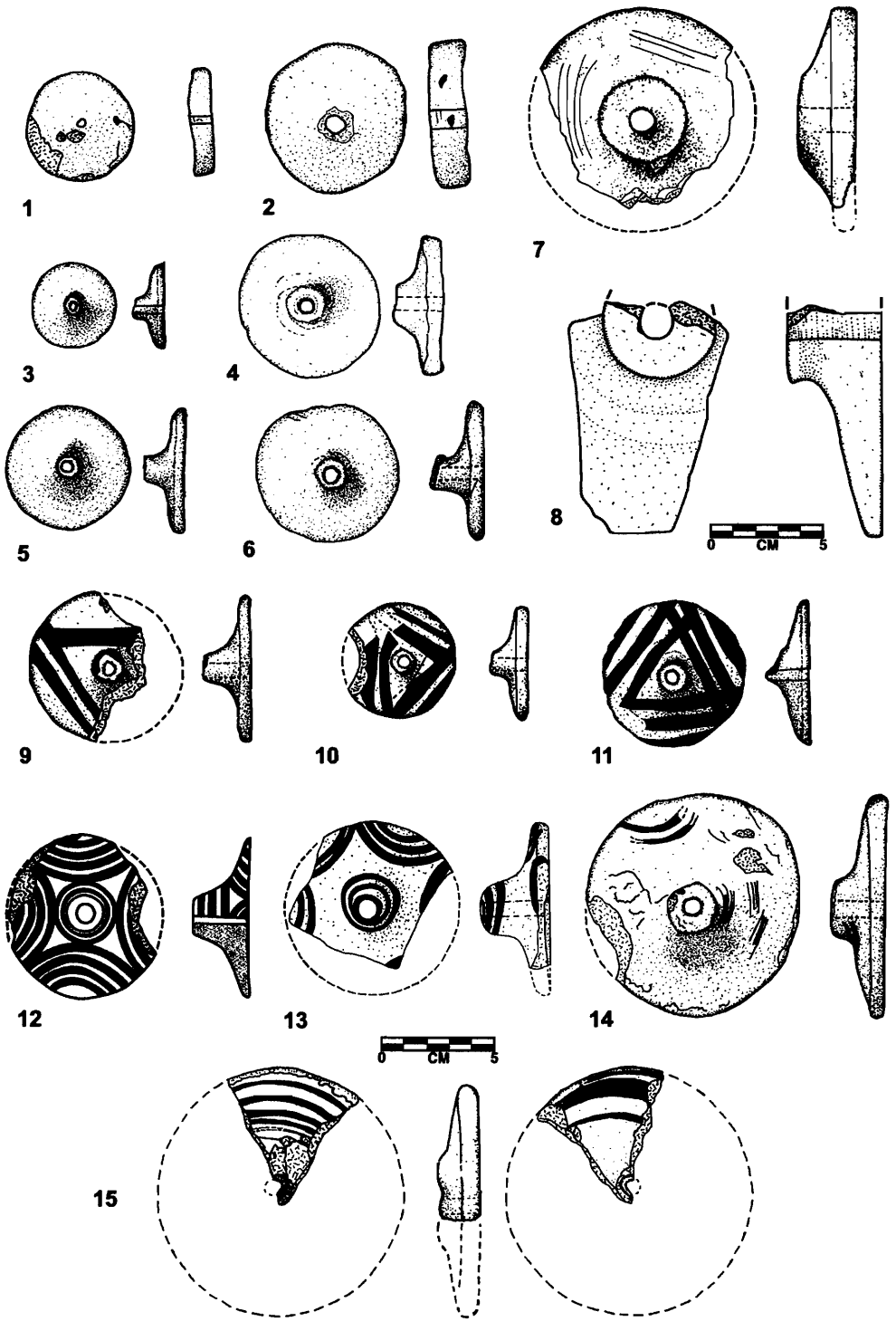

Figure 7. Harappa: Harappa Phase Wheel types, 2600-1900 BC

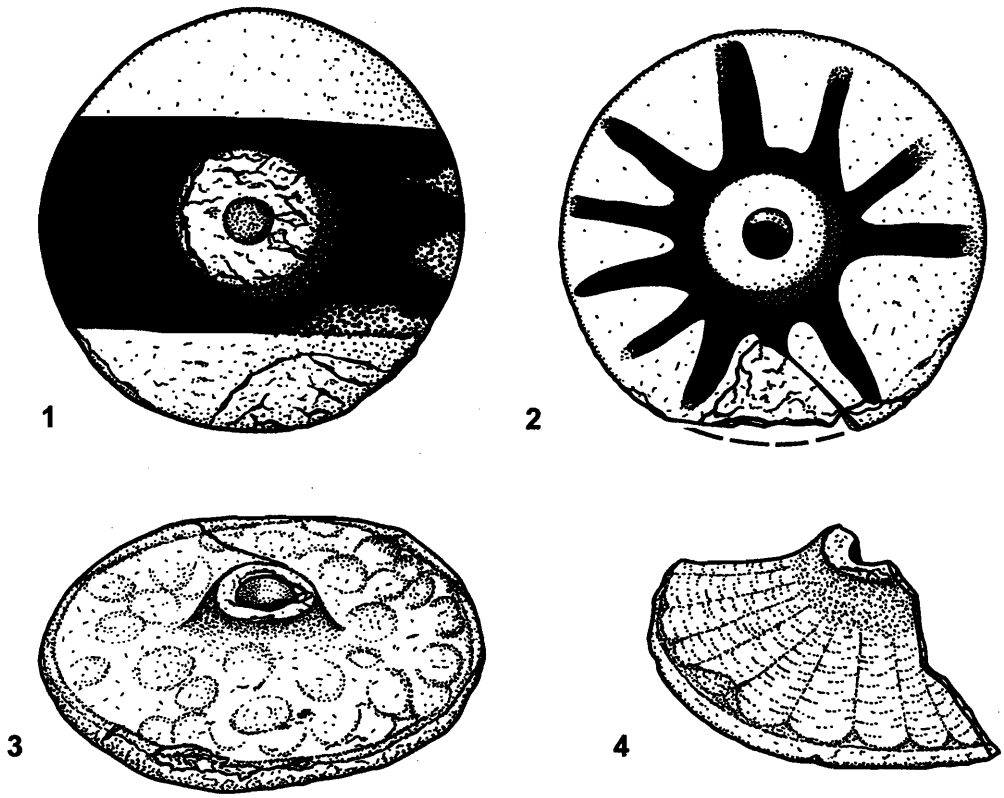

Figure 8. Indus Wheel Types.

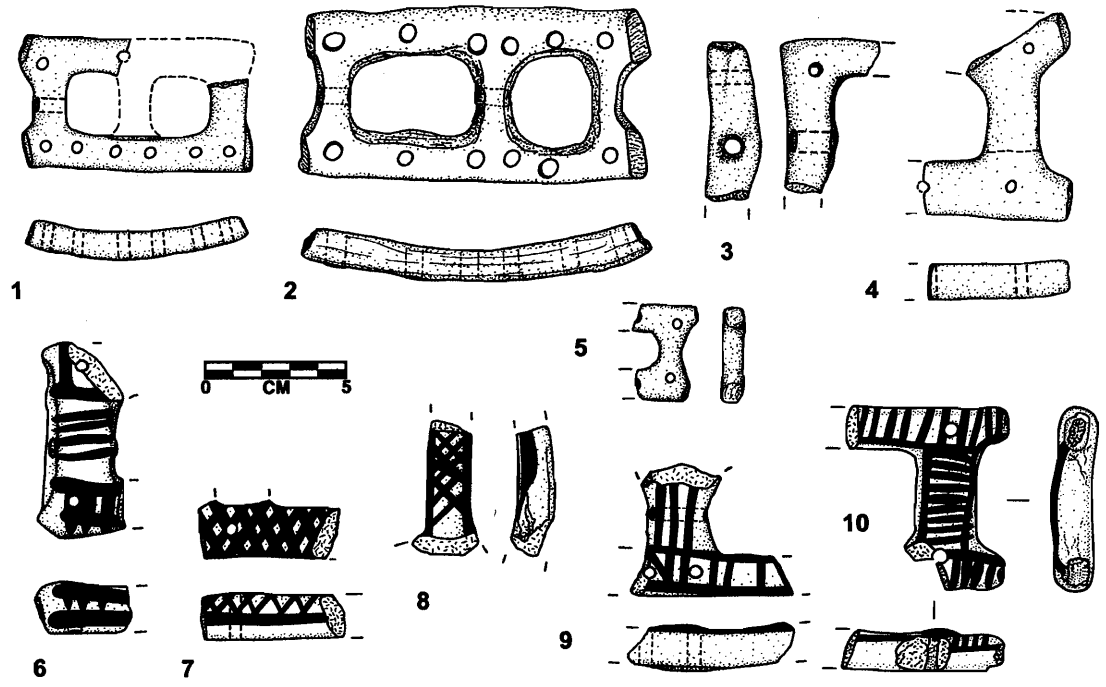

Figure 9. Harappa Carts: hollow frame chassis, terracotta, Harappa Phase.

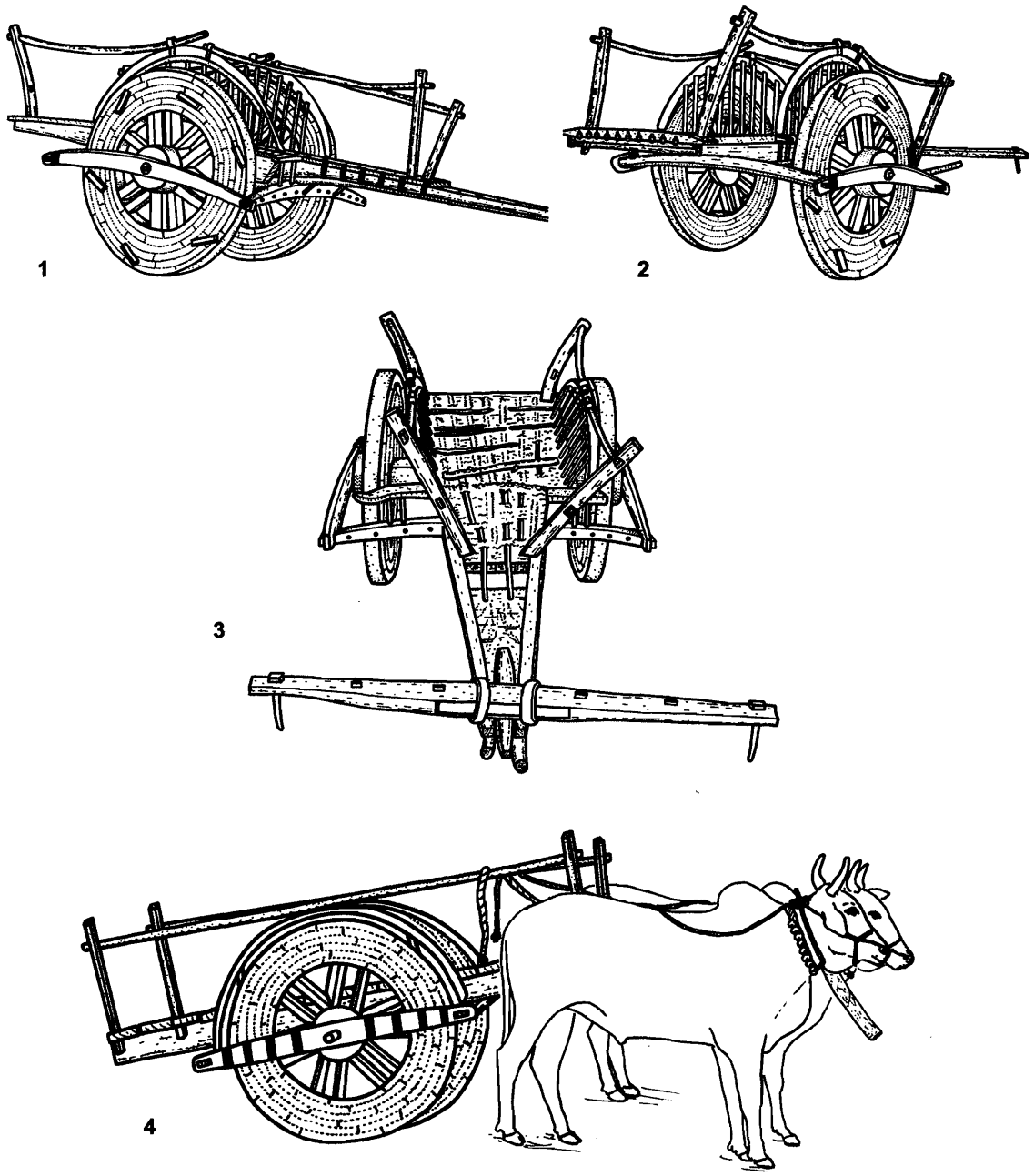

Figure 10. Modern Punjabi hollow frame chassis cart from Harappa, Pakistan.

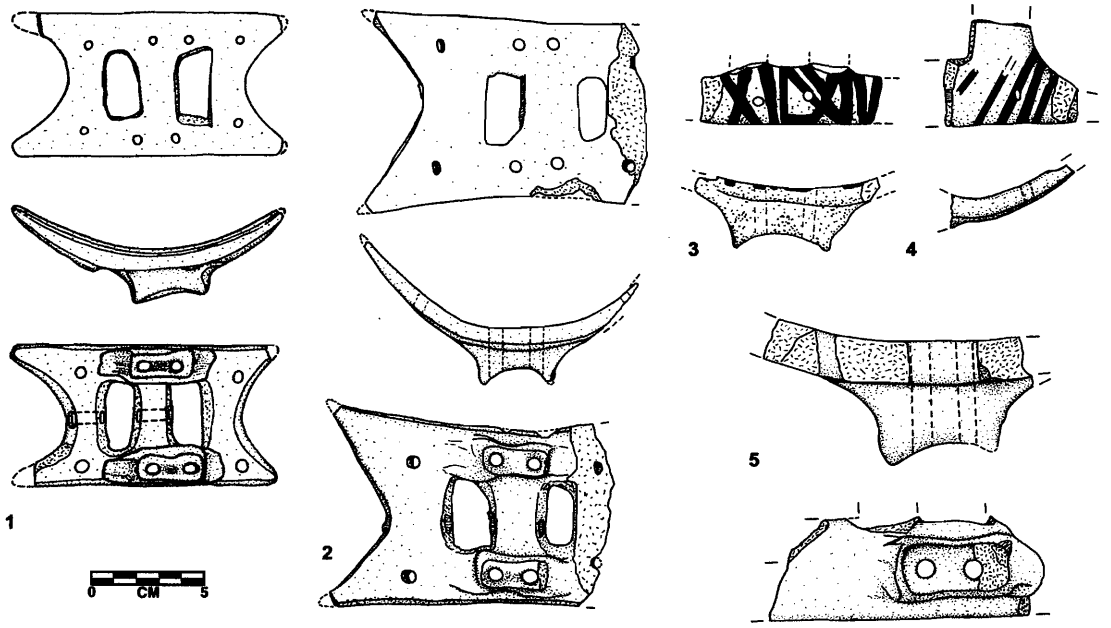

Figure 11. Harappa Carts: Hollow frame chassis with concave ends, terracotta, Harappa Phase.

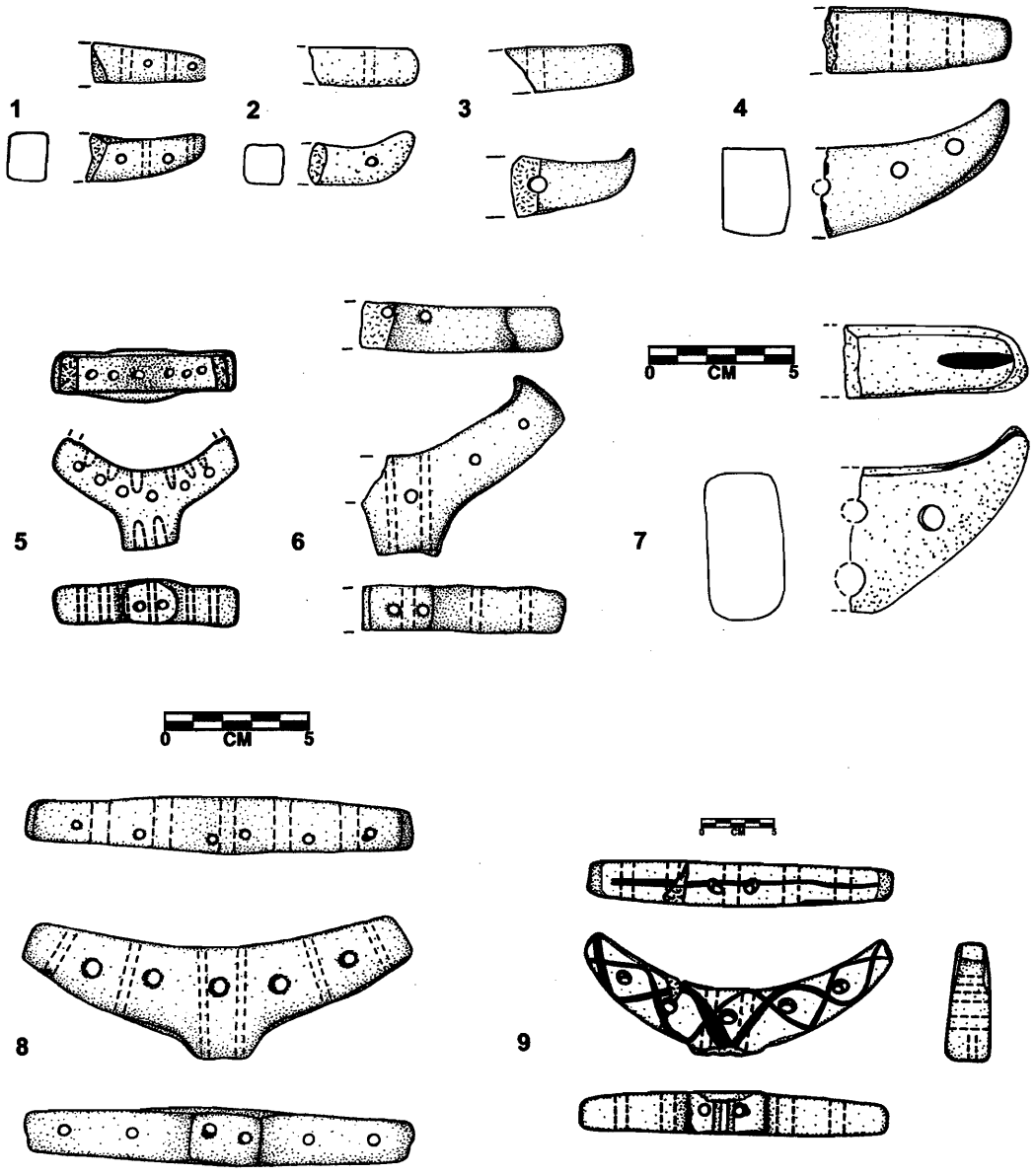

Figure 12. Harappa Carts: Double side frame chassis, terracotta, Harappa Phase.

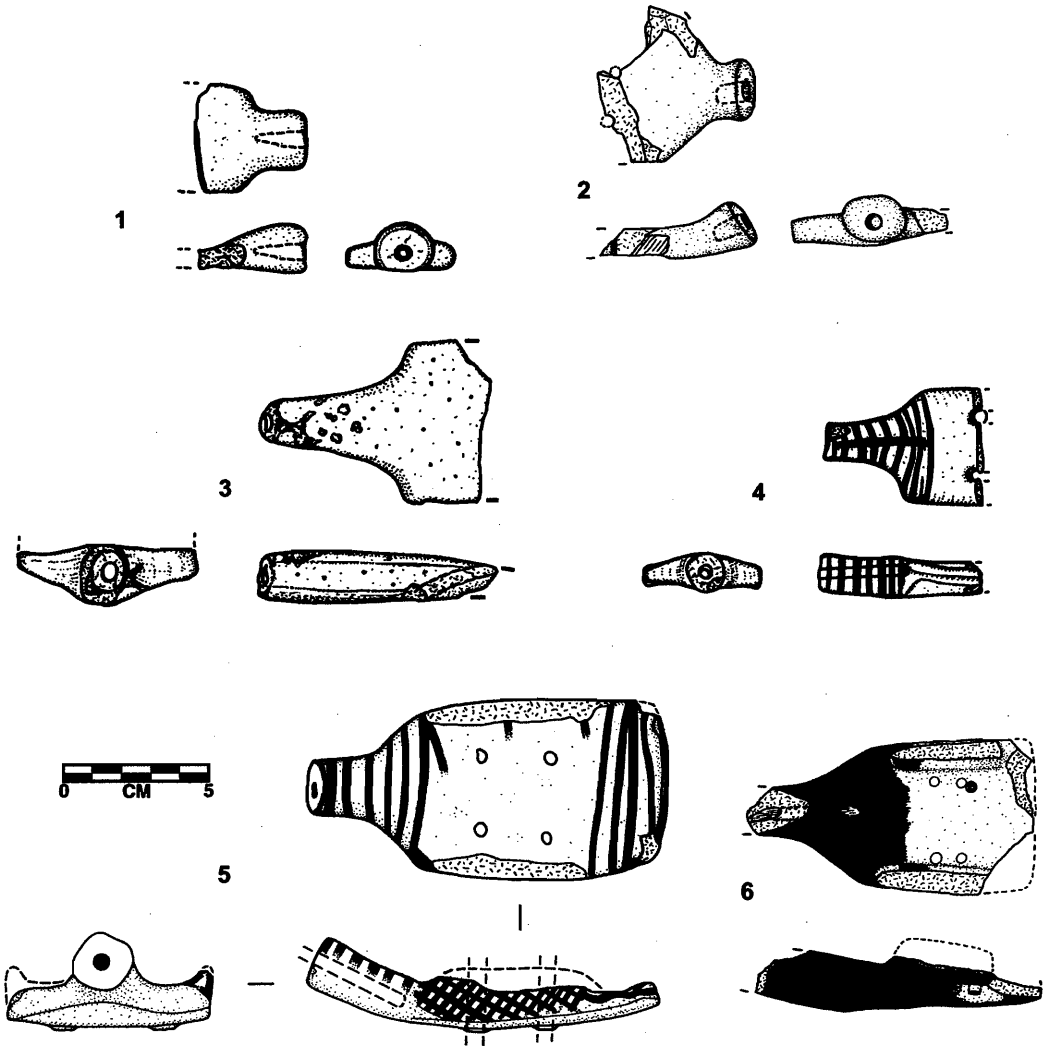

Figure 13. Harappa Carts: Solid frame chassis with side boards, terracotta, Harappa Phase.

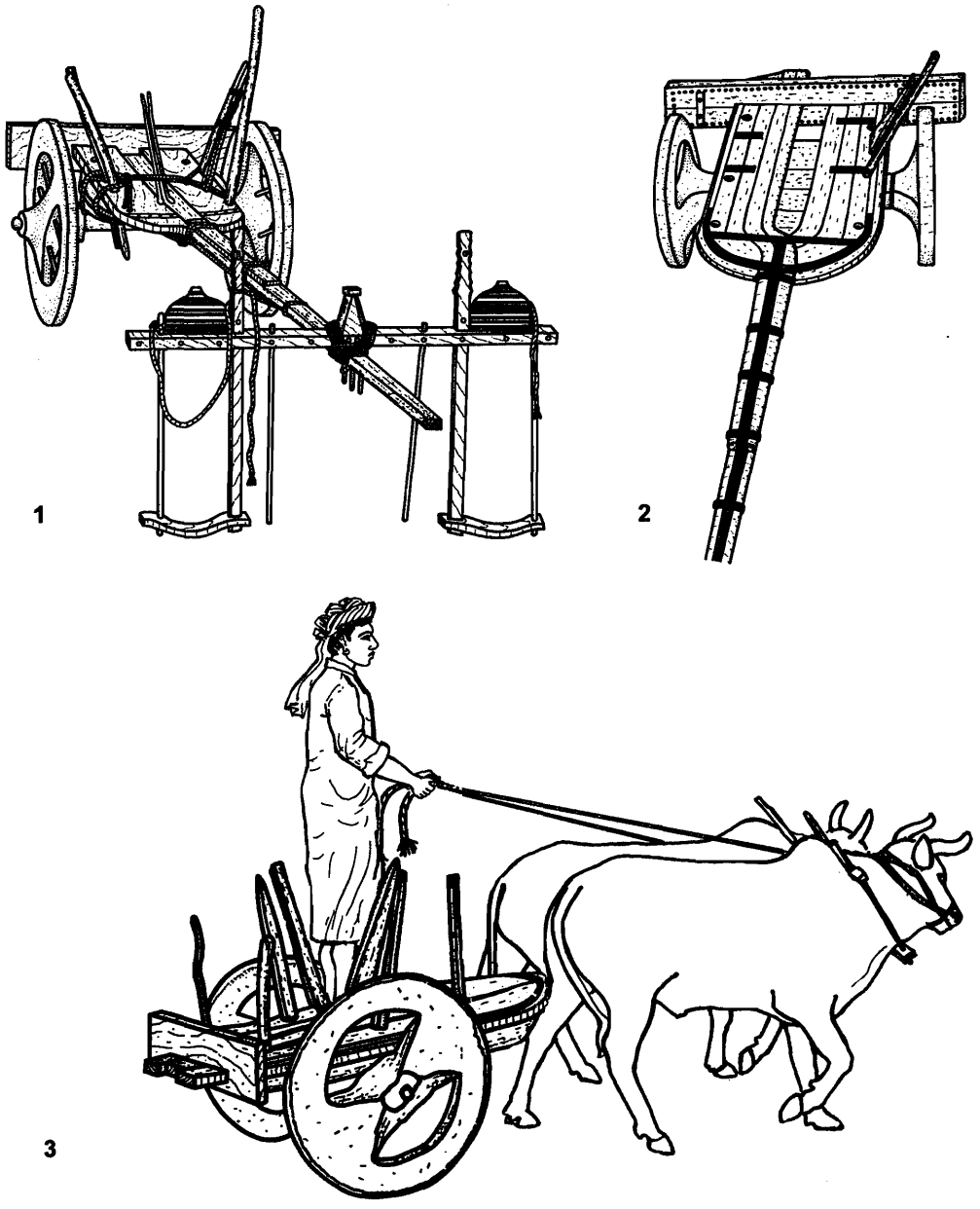

Figure 14. Modern Sindhi solid frame cart from Mohenjo-Daro, Pakistan.

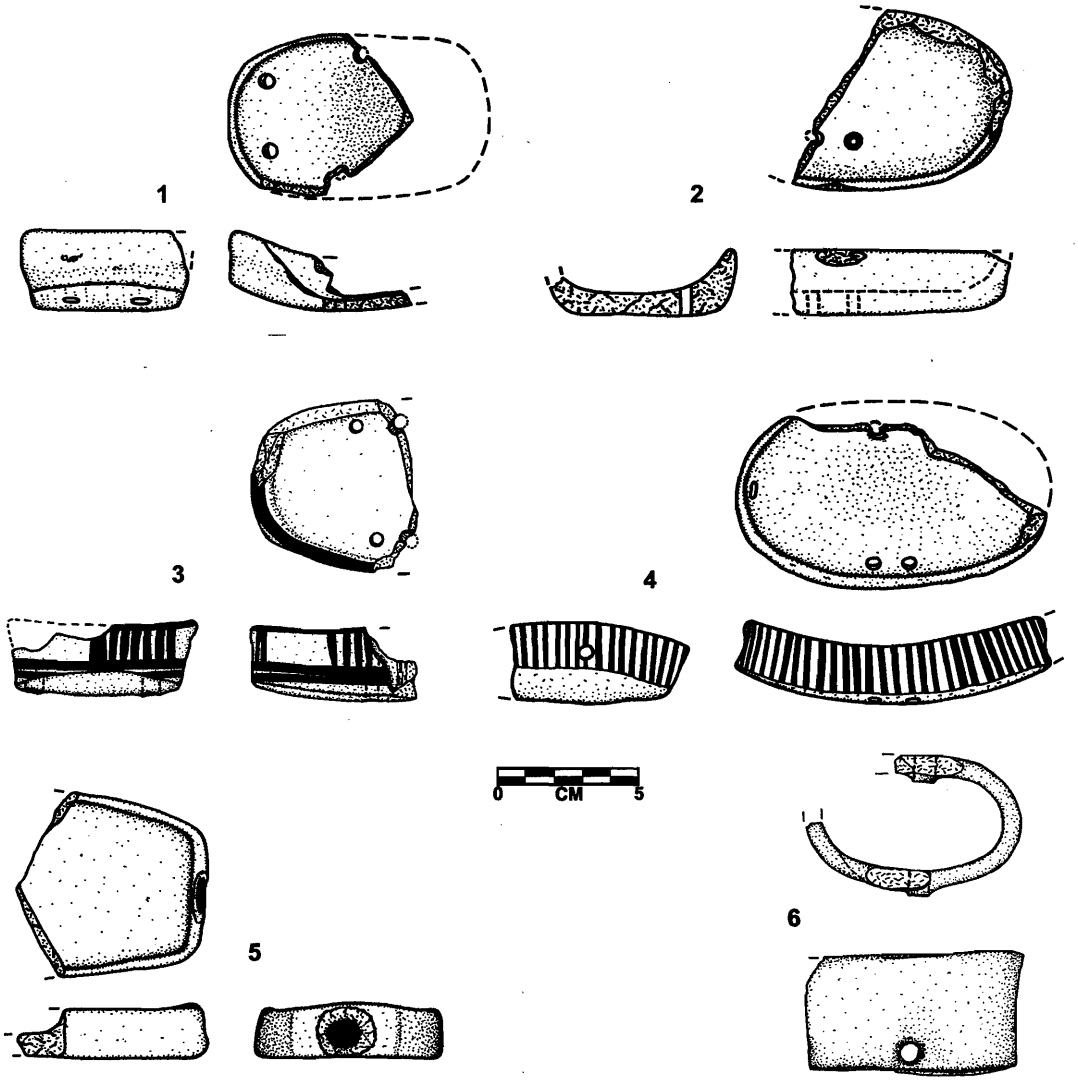

Figure 15. Harappa Carts: Oval, single compartment with low side walls, terracotta, Harappa Phase.

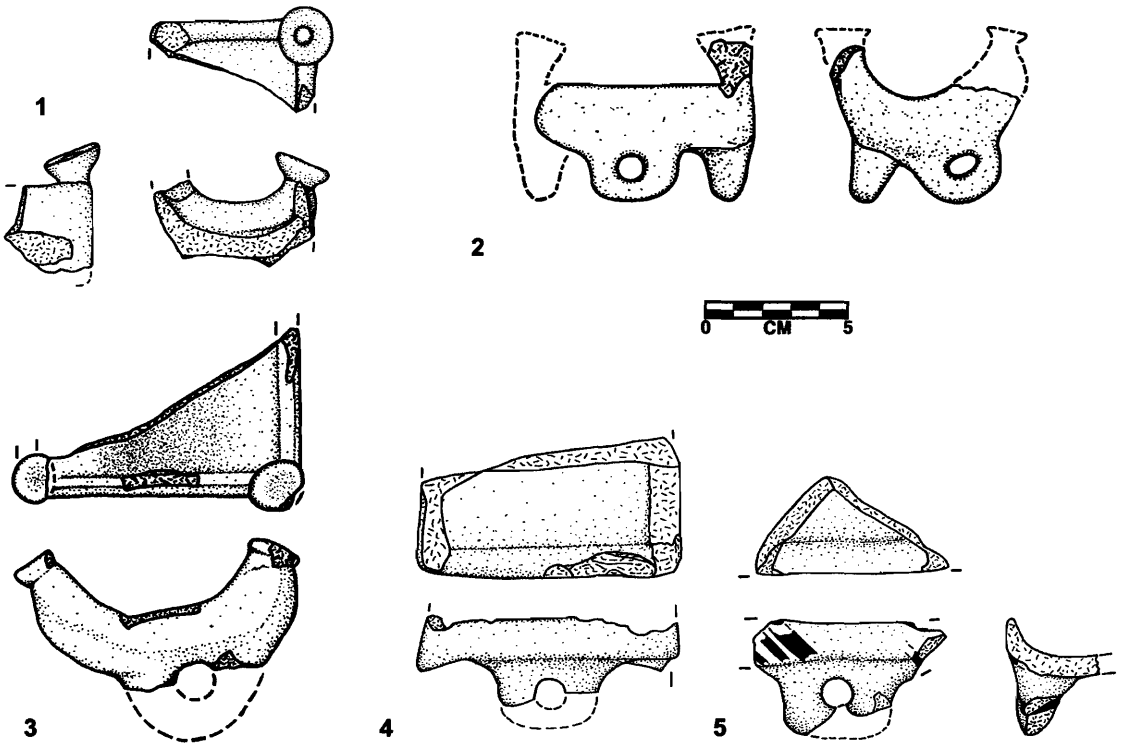

Figure 16. Harappa Carts: Four posted single compartment with low side walls, terracotta, Harappa Phase.

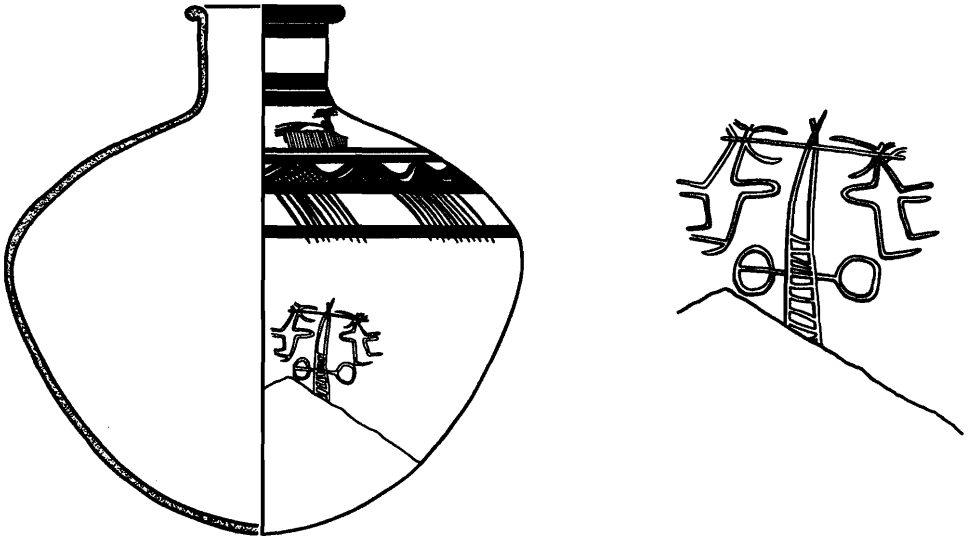

Figure 17. Inamgaon, Early Jorwe Period (circa 1500 BC) pot with bullock cart graffiti (after Sankalia, 1974: Fig. 204).